

EFFECT OF DIFFERENT WATER QUALITIES ON SOIL PHYSICAL PROPERTIES

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ABSTRACT

The quality of irrigation water (Salinity & Sodicity) has the potential to significantly affect soil structural properties. While the effect of electrolyte concentration (as indicated by the electrical conductivity *EC*) and sodium adsorption ratio (*SAR*) have been studied under laboratory conditions, the effect on soil profile structural properties have not widely investigated under field conditions. In this paper, water with three different water levels of sodium (*SAR* = 0.9, 10, 30) was applied as alternative treatments to a clay loam soil in furrow irrigation. Soil physical properties as surface bulk density, subsurface bulk density and Mean Weight Diameter (*MWD*), which is an index of aggregate stability were measured. The application of minimum to high *SAR* water was found to reduce aggregate stability, increase the bulk density of both the surface crust and underlying soil. *MWD* in the moderate and high saline-sodic treatments were decreased respectively about 17% and 53% during the irrigation season compared to the controlled period. Also, bulk density in surface layer increased by about 4% and 7% respectively using moderate and high sodic treatments than beginning. Both of these results indicate the impact of high *SAR_{iw}* on the collapse of soil structure and soil dispersion.

Keywords: Soil, Saline and Sodic water

INTRODUCTION

Saline irrigation water contains dissolved substances known as salts. In much arid and semi arid regions, most of the salts present in irrigation water are chlorides, sulfates, carbonates, and bicarbonates of calcium, magnesium, sodium and potassium. While salinity can improve soil structure, it can also negatively affect plant growth and crop yields. Sodidity refers specifically to the amount of sodium present in the irrigation water. Irrigation with water that has excess amounts of sodium can adversely impact soil structure making it difficult for plant growth. Highly saline and sodic water qualities can cause problems for irrigation, depending on the type and amount of salts present, the soil type being irrigated, the specific plant species and growth stage, and the amount of water that is able to pass through the root zone.

Under field conditions, irrigated soils are exposed to sequential periods of rapid wetting followed by drying. Soils which are subjected to these wetting and drying cycles have been found to exhibit low aggregate stability (Caron et al. [2]; Rasiah et al. [6]) resulting in the release of colloidal material and the collapse of soil pores (Levy and Miller [4]). However, the quality of the irrigation water applied will also affect the soil chemical properties which influence soil dispersion and aggregate breakdown, surface sealing and crust formation (Shainberg and Letey [7]).

Hence, few workers have been able to distinguish the physico-chemical impacts associated with the quality of the water applied (e.g. dispersion) from the physical impacts associated with wetting and consolidation (i.e. slumping, hydraulic sealing).

Furrow irrigation water quality affected soil cohesivity by altering clay dispersion (Malik et al. [5]; Shainberg et al. [8]) and aggregate stability characteristics (Smith et al. [9]).

Hence the objective of the work reported in this paper is to evaluate the effect of irrigation water quality (Salinity and Sodicity) on the soil structure properties under field conditions.

MATERIAL AND METHODS

This work was conducted on the Tehran University farm in Karaj, Iran. The soil at the trial site has a uniform clay loam soil texture (dominated by Illite and Chlorite) overlying a semi-permeable hard pan at 60cm. The trial work consisted of setting up 27 furrows (three water quality treatments with three replication) with a spacing of 0.75m, length of 30m and a slope of 0.01%. The beds were planted with maize and divided into nine plots. The soil properties is shown in Table 1.

Table 1. Selected initial soil physical and chemical properties in trial site

Sand	Silt	Clay	K	p	CEC	pH	EC	Depth
%			mg/kg		meq/100 g		(dS/m)	(cm)
29.2	45.4	25.4	204	8.2	13.0	7.9	0.56	0-30
25.2	47.4	27.4	128	3.6	13.0	7.9	0.95	30-60
SAR		Anions (meq/l)			Cations (meq/l)			Depth (cm)
		Cl ⁻	HCO ₃ ⁻	SO ₄ ⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	
0.92		5.0	2.8	0.7	3.6	3.2	1.7	0-30
1.16		4.0	2.4	8.0	6.4	5.2	2.8	30-60

Irrigation water was applied to all plots at the same time on 12 occasions during the season. No rainfall was received during the trial. Irrigation water qualities were applied at three different levels at low EC-SAR ($EC=0.6 \text{ dSm}^{-1}$ and $SAR=0.9$, *LS*), moderate EC-SAR treatment as *MS* ($EC=2.0 \text{ dSm}^{-1}$ and $SAR=10$) and high EC-SAR treatment as *HS* ($EC=6 \text{ dSm}^{-1}$ and $SAR=30$).

The development of a surface seal was identified by measuring the density of the soil formed by irrigation and the change in bulk density within the profile. To measure the surface seal density, two samples of the seal layer (0-5cm) were removed as clods from each treatment and oven dried at 100°C for 2 days. The clods were then coated in paraffin and volume displacement used to determine their densities (Blake and Hartge [1]).

Bulk density measurements were undertaken using a core (diameter = 5cm). The bulk density at the end of season was measured on the soil below the apedal surface layer (5-20cm). Changes in the aggregate stability at the surface soil was assessed using a wet sieve method (Kemper and Rosenau [3]). Surface soil samples were collected both before the first irrigation and after the last irrigation and crushed to pass through a 4.6 mm sieve. A 50g soil sample was put on the top mesh of sieve nest and immersed in distilled water. The sieves were then oscillated through a vertical distance at a rate of 30 rpm for a period of 10 min. The soil material on each sieve was collected, dried at 100°C for 2 days and weighed. The results were presented as the mean weight diameter (MWD) calculated according to Youker and McGuinness [10].

Analysis of variance (ANOVA) were conducted prior to the calculation for the soil physical data.

RESULTS AND DISCUSSION

The values of mean weight diameter which is an index of wet aggregate stability were analysed in the end of season.

The values of mean weight diameter using different water qualities are grouped in different classes (level of significance <0.01). This results shows that with increasing SAR values in irrigation water, mean weight diameter was decreased rapidly.

Mean weight diameter in all treatments showed a significant reduction with time through the season (Fig. 1). MWD in the moderate and high saline-sodic treatments decreased respectively, about 17% and 53% during the irrigation season compared to control (MWD in the beginning). The aggregate stability of the surface soil decreased during the season with the application of the low EC-SAR water. However, the application of the high EC-SAR water was associated with a decrease in MWD (0.267mm) to less than half of that measured for the soil irrigated with the low EC-SAR water (0.563 mm).

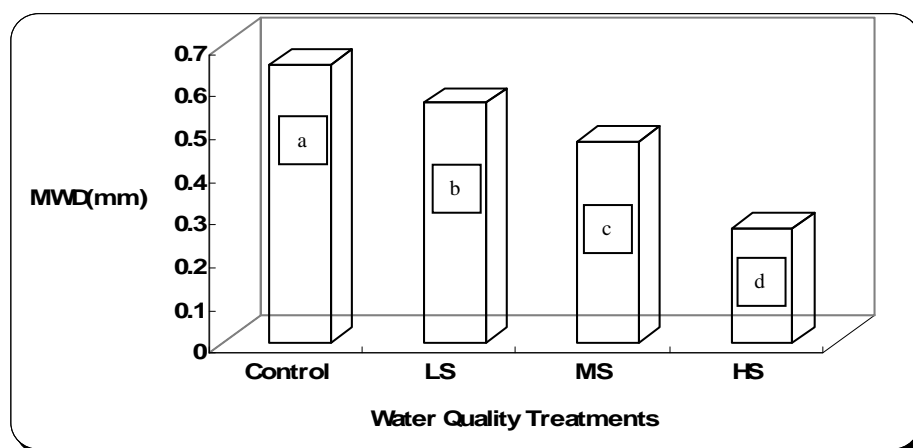


Fig. 1. Effect of water qualities on mean weight diameter

Aggregate slaking is one of the main mechanisms responsible for the breakdown of aggregates. Exchangeable sodium percentage (ESP) and electrolyte concentration (EC) of the soil solution play a significant role in determining soil physical properties and the response of soil clays to dispersion and swelling using waters with high SAR.

Also bulk densities analysis in surface (0-5cm) and subsurface (5-20cm) showed that high SAR waters caused increasing bulk densities in both surface and subsurface layer (Table 2).

Table 2. Variation of surface and subsurface bulk densities in water quality treatments (g.cm⁻³)

	Surface layer	Subsurface layer
Control *	1.38 a	1.33 a
LS	1.41 a	1.33 a
MS	1.44 ab	1.35 ab
HS	1.48 b	1.39 b

* : Measurement in the beginning

Bulk densities in surface layer increased by about 4% and 7%, respectively, with using moderate and high sodic treatments than beginning. Increasing bulk densities (Surface and subsurface) and decreasing mean weight diameter indicate the impact of higher SAR_{iw} on the collapse of soil structure and soil dispersion. The density of the soil (5-20 cm) underlying the apedal surface layer was related to the EC-SAR of the irrigation water, with the high EC-SAR treatment showing a statistically significant higher density of 1.39 g.cm⁻³ compared to 1.33 g.cm⁻³ for the low EC-SAR treatment.

Hence, the processes influencing structural breakdown in the layer are influenced by the chemical changes within the profile.

Sodium has the opposite effect on soils that salinity does. The primary physical process associated with high sodium concentrations in soil dispersion. Soil dispersion results from the breakdown of soil aggregates in water, leaving clay particles to disperse and settle into soil pore spaces between soil (aggregate breakdown and increase bulk density).

The relationship between ESP and subsurface bulk density of soil is shown in Fig. (2). Bulk density increased linearly with increase in exchangeable sodium percentage.

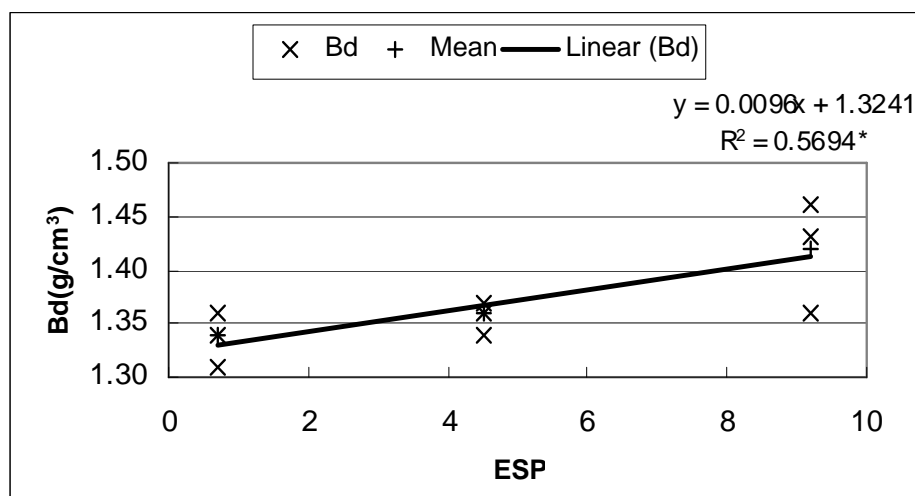


Fig. 2. Relation between ESP and subsurface bulk density

CONCLUSION

Irrigation water quality has been found to significantly affect soil physical properties. These changes occurred in the presence of high solute concentrations normally associated with maintaining soil aggregate stability and continued throughout the irrigation season. Soil dispersion causes clay particles to plug the soil pores, decrease the mean weight diameter and increase bulk densities. Salinity and sodicity affect soil structure, which must be stable for adequate permeability and water infiltration. High sodium levels combined with low soil-water electrical conductivity can lower a soil's permeability through the swelling and dispersion of clays and the slaking of the aggregates.

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